NUCLEAR HARMONIZATION & STANDARDIZATION INITIATIVE

Why Non-Nuclear Codes and Standards Are Important for Harmonizing SMRs

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1. SMR harmonization also needs to consider non-nuclear regulation

Small modular reactors (SMRs) represent reliable, low-carbon energy sources that are expected to be easily integrated with existing grid infrastructure as well as in remote locations or areas with relatively small electric grids. Their deployment is recognized as an enabler to achieving energy security and net zero objectives while meeting the increasing electricity and heat demands of diverse economies worldwide.[2] Currently, efforts are intensifying to establish an international market of SMR designs.

Maintaining a high level of nuclear safety is paramount. This is achieved through SMR plant and system design by applying nuclear safety design principles such as defense-in-depth, redundancy, diversity, separation and passive design features. A high level of safety is demonstrated via deterministic and probabilistic safety analyses. There are jurisdictional differences in terms of specific requirements for nuclear safety, but work is underway to leverage and harmonize regulatory safety reviews among IAEA Member States.[3]

The manufacturing, construction, and operation of nuclear power plants must also conform to a variety of non-nuclear legislations and regulations and codes & standards (C&S), which apply to industrial buildings and equipment, unless stipulated otherwise. Most often, non-nuclear C&S are not enforced by the nuclear regulator, but rather by other regulatory bodies, e.g. environmental or health & safety authorities.

The intent of this TG2 paper is to increase awareness of the important role of non-nuclear C&S in nuclear projects, list related challenges and identify potential avenues for solutions for the future SMR market.

2. What kinds of non-nuclear codes and standards may play a role

All industrial products and services are based on standards, which may include national appendices in international standards. Tailoring plant designs according to regional changes in non-nuclear codes and standards leads to extra redesign, which in turn increases cost.

As an example, exit routes and the related life egress distances often challenge plant layout design as the requirements in one jurisdiction may be quite different in another. For instance, although the travel distance requirements to the nearest exit may seem to be the same, differences can include details related to the fire sprinkler system or whether certain rooms are located underground. Fire and civil code requirements need to be considered in the layout design for all industrial buildings.

Different voltages and electrical frequencies must also be considered. For example, electric motors designed for 50 Hz are generally larger and heavier than those made for 60 Hz with the same power output, which affects space reservation and maintainability. Different voltage levels in different jurisdictions affect the layout design, for example requirements for placing transformers inside the plant and in the selection of materials. Environmental and chemical regulations may include bans on certain materials used in components like, for example, chrysotile asbestos in gaskets and breakers and fluoroalkyl (PFAS) substances used in seals and lubricants.

Designs need to consider all regulations, including those related to industrial health and safety. For example, regulation often leads to the redesigning of various lifting and rigging equipment, as maintenance and access for testing and inspection needs to be possible even in cases where the plant would otherwise be remotely controlled. Furthermore, there are differences in engineering standards among regions, such as which construction materials are permitted as well as sustainable procurement requirements. Materials used for the same purpose may vary, applied measurement units may differ, etc. Often, nuclear and conventional requirements may be intertwined. There are many direct and indirect consequences of the above differences, among others, on the design and on the

[1] This paper is not an IAEA publication. It reflects the consensus opinion of the members of the NHSI TG2. The views expressed do not necessarily reflect those of the IAEA or its Member States. [2] NetZero Nuclear. [3] Nuclear Harmonization and Standardization Initiative (NHSI)

supply chain. When coupled with owner-specific requirements, we get the final compendium of all requirements an SMR and its systems, structures and components (SSCs) must conform with. According to a recent TG2 discussion, more than two-thirds of the design parameters of a new SMR may be based on non-nuclear requirements and thus sensitive to variations between jurisdictions. TG2 is currently collecting material of these most significant non-nuclear C&S leading to design changes in a database and plans to continue the effort.

3. General approaches to cope with differing requirements

TG2 has discussed potential approaches to managing compliance with all legislative, regulatory and owner requirements in different jurisdictions and found them to fall broadly into four categories discussed below.

- We may speak of fit-for-purpose tailoring or project-specific approach, which require significant redesign to fit the local supply chain and C&S requirements. This is common in large nuclear power plant projects.
- In an enveloping approach, designers may develop the project specifications according to the most demanding requirements identified across the jurisdictions of interest. The challenge is that enveloping requirements are costly to fulfil.
- An approach to develop a design conforming with a reasonably comprehensive set of requirements may be used. This would include seeking exemptions from those national requirements that lead to major modifications. Exemptions may sometimes be sought with evidence showing conformance with the objective in some other way than what is considered normal practice in each jurisdiction. A variant of this may be a regional approach, in which a standard design conforms with a regional C&S ecosystem which may include a few tailored national modifications.
- A full standard “product-as-is” design approach would mean that no changes in the SMR design are made between jurisdictions or regions. The plant would be delivered with information and evidence that intends to show that safety and other objectives are adequately met with reasonable assurance and other properties are adequately and transparently shown. Microreactors might be test cases for this new approach.

4. What may key organizations do to improve the situation

There are many things that may be done proactively to make nuclear simpler. Project owners and operators need to seek early engagement with regulators and suppliers to facilitate readiness and identify imperfect alignment of regulations. This will strengthen the supply chain and lower permitting, project and quality risks. Technology developers also need to be ready to demonstrate adequate compliance with the requirements of the intended jurisdictions and engage early with key organizations.

Governments may seek alignment between different regulators so that a more transparent and harmonized set of requirements can be developed for SMRs. Operators and nuclear regulators may also decide to take an active role in harmonizing their requirements, e.g., between the areas of nuclear safety, occupational safety, environment, building codes and fire safety.

Finally, suppliers of products and services need to develop their capabilities, including by participating in industrial associations and similar early engagement mechanisms together with operators and technology vendors. International organizations need to continue working together in identifying challenges, sharing information, and exploring avenues for solutions.

5. Conclusion

There are numerous legislations, regulations and C&S which must be followed when designing an SMR, including non-nuclear regulations that are not necessarily enforced by national nuclear safety authorities. These C&S also have an impact on the way in which SMRs are constructed, operated and maintained, which currently makes it difficult to have standardized SMR designs that can be deployed across jurisdictions without considerable modifications. Further national, regional, and international efforts will be necessary to establish more harmonized frameworks – as has been done in other industries e.g. the aircraft industry – and facilitate SMR standardization.